

MONTHLY WEATHER REVIEW.

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No. 12.

INTRODUCTION.

This Review for December, 1893, is based on reports from 2,964 stations occupied by regular and voluntary observers. These reports are classified as follows: 154 reports from Weather Bureau stations; 40 reports from United States Army post surgeons; 2,067 monthly reports from state weather service and voluntary observers; 27 reports from Canadian stations; 218 reports through the Southern Pacific Railway Company; 458 marine reports through the co-operation of the Hydrographic Office, Navy Department, and "New York

Herald Weather Service;" 106 weekly reports from 36 U. S. Life-Saving stations; 2 reports from navigators on the Great Lakes; monthly reports from local services established in all states and territories; and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

The WEATHER REVIEW for this month has been prepared under the general editorial supervision of Prof. Cleveland Abbe. The statistical data is furnished by Records Division.

CHARACTERISTICS OF THE WEATHER FOR DECEMBER, 1893.

HIGH AND LOW AREAS.

The high areas for December have generally pursued either extreme southerly or extreme northerly paths, and the United States has, to a large extent, been under the influence of the dry, clear sky of the areas of high pressures.

The important low-pressure storm that passed over the Lake region on the 14th and 15th was made the occasion of special Lake Storm Bulletin No. V; it was followed by an extensive area of cold northwest winds, with snow.

The highest pressures, in connection with high area No. VIII, were reported as 30.96 at Swift Current, Assiniboia, on the morning of the 12th, 30.94 at White River, Ont., on the morning of the 13th, and 30.92 at Albany, N. Y., on the morning of the 14th, being one of the most decided, long-continued high pressures that has been recorded in December.

TEMPERATURE.

Temperatures were generally above the average throughout the United States south of latitude N. 43°, but were below the average north of that limit. The mean temperature at Saint Vincent, Minn., and probably to the northward was one of the lowest on record.

PRECIPITATION.

The rain and snow fall has generally been below the average for December, except in the northern part of New England, the Lake region, and westward to Dakota. The quantity of snow has been generally up to the average in northern sections, but below the average in the southern portion of the

region where snow falls, and the same may be said as to the depth of snow lying on the ground at the end of the month.

WINDS.

Among the highest winds reported during the month have been: 106 miles per hour, on the 1st, at Pikes Peak, Colo.; 84 miles from the south, on the 20th, at Fort Canby, Wash.; 64 miles from the southwest, on the 24th, at Amarillo, Tex.; and 60 miles from the north, on the 5th, at Kittyhawk, N. C.

CROPS.

The Weather Crop Bulletin for the month of December shows that the ground was covered with snow at the close of the month north of latitude 43°, but that the region in which winter wheat is raised was uncovered and, consequently, the seed and plants have been subjected to undesirable variations in temperature; fortunately, however, the reports generally state that the ground is dry and not frozen hard, the fall grains are doing well, and plowing is being well advanced during the fine weather.

INLAND NAVIGATION.

The rivers have generally remained below the danger line, the only floods reported having occurred in the Willamette River at Portland, Oregon, on the 4th, Buffalo Creek, N. Y., on the 16th, and Roseburg, Oregon, in the Coquille River, on the 5th. The Hudson River was closed for a few days in the latter part of the month; the upper Saint Lawrence was closed December 14, being one of the earliest dates on record.

ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean atmospheric pressure reduced to sea level for December, 1893, as determined from observations taken daily at 8 a. m. and 8 p. m. (75th meridian time), is shown by isobars on Chart II, which also gives the so-called prevailing winds, or those most frequently observed at each station.

The normal distribution of atmospheric pressure for De-

cember and the direction of the normal wind resultant for each station is shown on Chart V. This chart has been prepared by Prof. H. A. Hazen, who has also prepared all the others of this series preliminary to the publication by the Weather Bureau of specially prepared data and charts showing the meteorological and climatic features and conditions of the United States. The pressures for both Canada and

the United States are reduced to sea level, but not to standard gravity, by Prof. Hazen's methods and formulæ. The resultant wind directions are as given by him at page 124 of his "Meteorological Tables," and are computed by Lambert's formula, giving equal weight to each observed wind without regard to its velocity.

As compared with the preceeding month of November the mean pressure for December, 1893, was generally higher throughout the United States, the maximum change being $+0.13$ in Florida and southern Texas and $+0.15$ in northern Wisconsin and Manitoba. Pressure had fallen slightly on the New England coast, appreciably in Nova Scotia and Montana, and decidedly in Alberta and western Assiniboia.

As compared with the normal for this month the pressures for December, 1893, have been in excess by $+0.10$ or more on the coasts of Washington, Oregon, and Louisiana; also, in the interior of Georgia and South Carolina. Pressures have been about normal over the central portion of the Lake region, Iowa, Kansas, Colorado, and thence northwest to Alberta. The maximum deficit has been -0.10 or -0.15 in Assiniboia and northern Montana.

PATHS OF HIGH AND LOW AREAS.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.										
I.....	1, a. m.	0	0	3, p. m.	0	0	Miles.	Days.	Miles.	Miles.
II.....	1, a. m.	42	96	3, p. m.	44	58	2,100	2.5	840	37
III.....	1, a. m.	34	123	6, p. m.	36	73	4,500	5.5	820	34
IV.....	4, a. m.	48	83	5, p. m.	47	62	1,100	1.5	733	31
V.....	4, p. m.	44	123	7, p. m.	30	93	2,200	3.0	733	31
VI.....	5, a. m.	51	102	8, p. m.	43	67	2,200	3.5	627	27
VII.....	7, a. m.	42	121	11, p. m.	35	75	2,300	4.5	511	21
VIII.....	8, a. m.	53	101	11, p. m.	47	75	1,400	3.5	400	17
IX.....	11, a. m.	53	113	14, p. m.	42	67	2,450	3.5	700	29
X.....	13, p. m.	52	113	14, p. m.	53	90	600	1.0	600	25
XI.....	14, p. m.	42	126	25, a. m.	33	81	5,200	10.5	495	21
XII.....	20, a. m.	42	110	21, a. m.	41	108	.....	.....	.....	.....
XIII.....	21, a. m.	54	96	23, a. m.	44	65	1,750	2.0	875	36
XIV.....	23, a. m.	41	116	28, p. m.	27	82	3,200	5.5	508	21
XV.....	24, a. m.	54	98	28, p. m.	27	82	2,400	4.5	533	22
XVI.....	26, a. m.	43	108	27, a. m.	42	105	.....	.....	.....	.....
XVII.....	29, p. m.	47	123	31, a. m.	30	103	1,500?	1.5	1,000	42
XVIII.....	29, a. m.	54	102	31, a. m.	50	65	1,600	2.0	800	33
Sums.....							34,500	54.5	10,175	.....
Mean of 15 paths.....									678	28.2
Mean of 54.5 days.....									633	26.4
Low areas.										
I.....	1, a. m.	48	124	4, a. m.	48	61	3,300	3.0	1,100	46
II.....	1, a. m.	43	74	2, a. m.	44	62	700	1.0	700	29
III.....	2, p. m.	49	113	6, a. m.	47	80	1,700	3.5	488	20
IV.....	5, a. m.	35	73	6, a. m.	47	57	1,200	1.0	1,200	50
V.....	5, a. m.	33	100	6, p. m.	29	88	950	1.5	622	26
VI.....	6, p. m.	48	113	11, p. m.	46	56	3,100	5.0	620	26
VII.....	10, a. m.	43	118	13, a. m.	47	54	3,400	3.0	1,133	47
VIII.....	12, a. m.	47	125	14, a. m.	47	123	.....	.....	.....	.....
IX.....	14, a. m.	44	108	17, a. m.	43	60	2,700	3.0	900	38
X.....	15, p. m.	47	112	.....	.....	.....	.....	.....	.....	.....
XI.....	17, a. m.	49	108	20, p. m.	47	58	2,500	3.5	715	30
XII.....	19, p. m.	50	111	21, p. m.	45	59	2,800	2.0	1,400	58
XIII.....	20, a. m.	44	125	24, a. m.	45	57	3,300	4.0	825	34
XIV.....	23, a. m.	43	104	26, a. m.	46	59	2,500	3.0	833	35
XV.....	23, p. m.	47	128	29, a. m.	45	63	3,200?	5.5	600?	25?
XVI.....	26, p. m.	38	125	.....	.....	.....	.....	.....	.....	.....
XVII.....	28, a. m.	49	111	29, a. m.	43	98	1,000	1.0	1,000	42
XVIII.....	30, a. m.	47	106	31, p. m.	46	105	.....	.....	.....	.....
XIX.....	30, a. m.	32	88	.....	.....	.....	.....	.....	.....	.....
Sums.....							32,350	40.0	12,136	.....
Mean of 14 paths.....									867	36.1
Mean of 40.0 days.....									809	33.7

The paths pursued by centers of high and low pressure during December, 1893, are shown on Charts IV and I, respectively, and the duration and velocity are given in the table at the end of this chapter. The charts show by small circles the positions of the centers. Within the circles are given the pressures reported nearest the centers and the corresponding dates. If a decided trough of low pressure or

ridge of high pressure exists at that time its location is shown by a short wavy line through the center. Sometimes distant centers are connected by such ridges or troughs, but in such cases the middle portion of the wavy line is omitted to avoid confusing the map.

HIGH AREAS.

I.—This was central on the 1st as a ridge from western Missouri to Saskatchewan, and was a continuation of high area No. VIII of the November REVIEW; the maximum pressure was then in Iowa. The center of the ridge moved southeastward, and on the morning of the 2d was in eastern Maryland, after which it turned northward over New England and disappeared on the 3d, in the afternoon, southeast of Newfoundland.

II.—The edge of an encroaching high area from the Pacific appeared off the California coast on the morning of the 1st. By the 2d, a. m., the highest pressure was near the coast of Oregon, it then moved rapidly eastward and on the 3d, a. m., was in Utah. During that day while the pressure varied but little on the Pacific coast it rose rapidly in Texas, and on the 3d, p. m., and 4th, a. m., a ridge of high pressure prevailed from Oregon to the Gulf coast, while another ridge developed from Texas northeast over Lake Huron, thus partially encircling the low area No. III, which was then central in Manitoba. A severe norther on the Gulf coast was caused by the advent of this high area. During the 4th and 5th the eastern ridge continued to exist, dividing the two low areas Nos. III and V, but by the morning of the 6th the high pressure over the Gulf of Saint Lawrence had disappeared, leaving the southern end of the ridge, as a high, central in the eastern part of North Carolina. On the 6th, p. m., this high pressure was off the North Carolina coast.

III.—On the 4th, a. m., pressure had risen north of Lake Huron while it was falling to the westward. By the 4th, p. m., a high pressure was central near Montreal, and a ridge connected this with high area No. II in the Gulf of Mexico, as before described. This center disappeared on the 5th, p. m., near Newfoundland.

IV.—When high area No. II was central in Texas on the 4th, a. m., a ridge connected it with the high pressure off the coast of Oregon, where pressure was again rising, and on the 4th, p. m., an independent high center was located there. On the 5th, a. m., the center was on the boundary between Oregon and Washington, and a second high area had developed on the east side of the Rocky Mountains, its center being at that time in Assiniboia. The data at hand are not sufficient to decide whether this latter area of high pressure was due to cold air near the surface of the earth drawn southward over Saskatchewan in the rear of low area No. III, which was then central in northern Minnesota, or whether it was due to a flow of air in the upper strata from the Pacific coast eastward over the Rocky Mountains; in the latter case this high area would be considered as a branch of high area No. IV; but I incline to the former hypothesis, and, therefore, I number it as an independent area (No. V). High area No. IV moved southeastward over Utah and was central in Texas on the 6th, p. m., and 7th, a. m., and on the coast of Louisiana on the 7th, p. m., after which it disappeared.

V.—Was central on the 5th, a. m., in Assiniboia; it had scarcely moved by the 6th, a. m., while the flow of cold air southward had caused a subsidiary high center to be formed in northern Missouri. These two centers moved eastward, the northern one more rapidly than the southern one, and on the 8th, a. m., they had joined in forming a ridge of high pressure extending from Virginia to the Valley of the Saint Lawrence. On the 8th, p. m., the highest pressure was off the New England coast, and moved thence northeastward beyond the limits of our stations.

VI.—While high area No. IV was central on the 6th in Texas

a ridge of high pressure extended thence northwest to Oregon and beyond, and the center of a new area may be located on the southern border of that state on the 7th, a. m., and 7th, p. m., while the ridge of high pressure continued to extend thence southeast to the Gulf of Mexico. The center of this ridge of high pressure remained nearly stationary between Oregon and northern Nevada until after the morning of the 9th, after which the pressure steadily diminished on the Pacific coast but rose somewhat at the southeast extremity of the ridge until, on the 10th, a. m., the highest pressure was central in Texas; after this it moved eastward, and on the 11th, p. m., it was off the coast of North Carolina, having united with high area No. VII.

VII.—During the 6th and 7th low area No. VI moved southeastward through Alberta and Assiniboia, and high areas Nos. IV and V developed, respectively, on the southwest and northeast sides of this low, as has been before mentioned; similarly in the rear of this low area and on the west and north sides, respectively, high areas Nos. VI and VII developed, so that on the morning of the 8th, while high area No. VI was central in southern Oregon, high area No. VII was central in the northern part of Manitoba; evidently the southwest movement of upper air, impinging on the coasts of Alaska and British Columbia in its circulation around the low area of the north Pacific, had in part been deflected southeastward by the resistance of the continent and contributed to the formation of high area No. VI, while it had also in part passed over the mountains into the interior of Saskatchewan and contributed to the formation of high area No. VII. (A process explained in *American Meteorological Journal*, 1892, VIII, pp. 551–552, or *American Journal of Science*, 1892, XLIII, p. 377.) These areas of high pressure continued to develop while low area No. VII, following after low area No. VI, moved between them southeastward over the Rocky Mountain region. High area No. VII was central in Manitoba on the 9th and 10th, a. m. It was north of Lake Superior on the 11th, a. m., at which time a ridge of high pressure extended south to high area No. VI, which was then central in South Carolina. On the 11th, p. m., high area No. VII was central north of Montreal, but pressure was rapidly diminishing; after this it disappeared.

VIII.—On the 9th low area No. VII developed in Alberta between high areas No. VI and VII; as soon as it had passed southeast into Wyoming on the afternoon of the 10th high area No. VII, whose center was then in Manitoba, was greatly reinforced by the approach of still higher pressure from the north, while at the same time the barometer which had been somewhat below the normal in Oregon began to fall still faster. High area No. VIII, which we place in Alberta on the 11th, a. m., may also be considered as the western end of the larger area, which at that time included high area No. VII, and extended as a long ridge from Alberta to James Bay, with another branch extending farther southeast so as to include high area No. VI, then in South Carolina. The farther progress of low area No. VII was followed by a great barometric rise from Assiniboia to Iowa, the central highest pressures being 30.96 at Swift Current, Assiniboia, on the 12th, a. m., and 30.92 at Minnedosa, Manitoba, on the 12th, p. m.; 30.94 at White River, Ontario, on the 13th, a. m., and 30.84 at Rockliffe, Ontario, on the 13th, p. m. On the 14th, a. m., the highest pressure was at Albany, N. Y., and in the afternoon it disappeared off the New England coast.

IX.—While low area No. IX was central in Wyoming on the 14th, a. m., pressure was rising rapidly to the northward, as well as on the Pacific coast, and high area No. IX moved south and east over Alberta and Saskatchewan into Manitoba, where it disappeared.

X.—This area developed on the 14th on the west side of the trough constituting low area No. VIII, and seems to have advanced directly eastward from the Pacific Ocean. It was cen-

tral on the 15th, a. m., in southeastern Oregon, and on the 16th, a. m., in northeastern Nevada, but stretching as a remarkable ridge of high pressure from Washington to Texas. The sudden appearance, rapid growth, stationary center, and prolongation parallel to the Rocky Mountain range, make this high area an excellent example of those high areas that are supposed to be formed by the slow descent of a broad upper layer of cooling air. In the present case, this upper layer is conceived of as moving from the southwest or west-southwest from the Pacific Ocean over California and Oregon on the night of the 14th, and to have reached the earth's surface first in Oregon and Nevada on the morning of the 15th, and in Colorado and New Mexico by 8 p. m. of that day; the center of the slowly descending current continued during the 16th, a. m. and p. m., and the 17th, a. m. and p. m., with very slight change of position in Idaho, Utah, and Nevada. During the 18th, however, the area of high pressure spread northward beyond Alberta, southward into Mexico, and eastward to the 100th meridian while retaining its western boundary on the Pacific coast; on the 18th, p. m., the highest pressure was confined to a small region in southern Alberta on the eastern slope of the Rocky Mountains, and this transfer of the central highest pressure northward must not disguise the fact that the great mass of air above was actually in motion toward the east and that, therefore, on the 19th, a. m., the center was in Nebraska. The eastern motion continued steadily, and on the 20th, a. m., the highest pressure was in Ohio, but the pressure had not diminished over the Rocky Mountain region and high area No. XI was located that morning as a separate area central in Utah and forming the western nucleus of a region of high barometer that covered nearly the whole of the United States. The center of high area No. X remained for five days slowly settling southward and eastward, until on the 25th it disappeared off the coast of the south Atlantic states.

XI.—This was the western portion of high area No. X; it remained central in Utah during the 20th, and had disappeared by the 22d by the gradual and general fall of pressure.

XII.—This began on the morning of the 21st as a slight elevation north of Manitoba between low area No. XII at the mouth of the Saint Lawrence and low area No. XIII in northern Alberta. On the morning of the 22d the center was north of Montreal, and at 8 p. m. of the 22d, in northern New Brunswick, but pressure had at that time risen, especially in Nova Scotia and southern Maine, and on the 23d, 8 a. m., the highest pressure was over Nova Scotia, after which it disappeared.

XIII.—On the 22d pressure rose off the Pacific coast, and high area No. XIII was central in Nevada on the 23d, 8 a. m., while to the northward pressure was also rising rapidly in Alberta. This latter seems to have had an independent origin, as a part of high area No. XIV and the two centers (after being joined by a ridge of high pressure on the 25th) finally united entirely on the 26th in northern Missouri and Wisconsin. The general movement of high area No. XIII was southeastward into Texas, while the movement of high area No. XIV was more rapidly southeast to the point of junction in Missouri.

XIV.—Pressure rose in Manitoba on the 23d, but the high center was apparently farther north; it moved southward into Missouri, joined high area No. XIII, and thence moved slowly southeast until it disappeared on the 28th in southern Florida.

XV.—This appeared on the 26th as the western extremity of a ridge extending from high area No. XIV in Missouri westward through Colorado and northwest to British Columbia. It apparently represents a new descent of the upper air along the Rocky Mountain ridge, while low area No. XVI was off the California coast. The center remained in Wyoming during the 27th and then disappeared.

XVI.—Pressure rose on the 27th off the California coast until it was highest on the 29th, p. m., on the coast of Oregon.

On the 30th, a. m., the center was in Nevada, whence it stretched southeastward until the 31st, a. m., when it disappeared in western Texas.

XVII.—On the 28th pressure rose in Saskatchewan, and during the 29th, a. m., was central in northern Manitoba. On the 30th, a. m., the center was northeast of Lake Huron, and on the 31st, a. m., it disappeared at the mouth of the Saint Lawrence.

LOW AREAS.

I.—This area of low pressure was central on the coast of Washington on the 1st, a. m.; it moved rapidly southeast as a long oval, trending northwest and southeast into northern Texas. On the 2d, p. m., it was central in Arkansas as a long oval, trending northeast and southwest, and had already begun its northeastward movement. On the 3d, p. m., it was central in eastern New York, and disappeared on the 4th, a. m., in the Gulf of Saint Lawrence, whence it probably moved eastward over Newfoundland.

II.—On the 1st, a. m., a trough of low pressure extended from Pennsylvania to New Brunswick, the lowest pressure being in the latter region, with evidences of a subsidiary center developing in central New York. On the 1st, p. m., a well-marked center was off the coast of New England; on the 2d, a. m., it was off the coast of Nova Scotia, after which it disappeared from our map.

III.—Pressure fell during the 3d in Montana, Alberta, and surrounding regions, and on the 4th, a. m., a deep depression was central in eastern Assiniboia; the 4th, p. m., near Lake Superior. The rapid southeasterly movement now became much slower, while low area No. IV was passing along the middle Atlantic coast, and low area No. III gradually filled up, disappearing on the 6th north of the lower lake region.

IV.—On the 4th, a. m., the northwest wind on the south Atlantic coast in the rear of low area No. I apparently determined the formation of an area of rain, whirling winds, and low pressure at the southern end of the trough containing low area No. I. It is, however, possible that this storm-center existed at some distance east of the coast on the 3d, and was already moving northward on the 4th. On the 5th, a. m., its center was located some distance east of Cape Hatteras; on the 5th, p. m., it approached Nantucket; and on the 6th, a. m., it was between Cape Breton and Nova Scotia, after which it disappeared.

V.—On the 4th, p. m., a slight depression began to develop in the interior of Texas and may be located on the 5th, a. m., in the northern part of that state. It moved south and east into the Gulf and disappeared on the 6th.

VI.—On the 6th, a. m., pressure was falling in British Columbia and eastward and southeastward, forming a trough whose center may be located on the 6th, p. m., in Alberta. Its southeast movement continued until the 8th, p. m., when it was central in Iowa, after which it turned northeastward over the Lake region and passed on the 10th, p. m., over the mouth of the Saint Lawrence; it disappeared on the 11th, p. m., off the southern coast of Newfoundland.

VII.—In the rear of low area No. VI a trough extended northwestward into British Columbia on the 9th, out of which there developed low area No. VII, whose center is located on the morning of the 10th on the northern border of Washington. After moving southeast into Nebraska it turned off eastward on the 11th and was central 12th, a. m., in the state of New York. The map of the 12th, p. m., shows a low area on the coast of Nova Scotia which disappeared on the 13th, a. m., south of Newfoundland and was probably the continuation of low area No. VII.

VIII.—Pressure fell on the coast of Washington after the 11th, p. m., and low area No. VIII was located there on the 12th, a. m. The pressure fell slowly without any decided movement of the center until the 14th, a. m., after which this low

area filled up and disappeared at that spot. Meantime its extension southeastward had given rise to a separate low center (No. IX) located in Wyoming on the 14th, a. m.

IX.—This center moved southeastward into Nebraska and was central on the 15th, a. m., in Iowa, whence its path turned northeastward, and on the 15th, p. m., the center was on Lake Michigan, with high winds and gales throughout the Lake region. On the 16th, p. m., the center was near the northern boundary of New Hampshire, and on the 17th it passed over the Gulf of Saint Lawrence and Newfoundland and disappeared.

X.—On the 15th pressure fell in Alberta and by 8 p. m. a moderate depression was central in that province, but it seems to have immediately filled up or possibly moved rapidly eastward and disappeared.

XI.—This depression was apparently central north of Alberta on the 16th, p. m.; in Saskatchewan on the 17th, a. m.; Manitoba on the 17th, p. m. By the 18th, p. m., it was central on the northern border of Lake Huron and a severe storm raged over the Lake region and southward to the Ohio and Missouri rivers. The path of the center now turned northeastward and was over New Brunswick on the 19th, p. m.; it disappeared off the southern coast of Newfoundland on the 20th, p. m.

XII.—On the 19th pressure fell in Saskatchewan and Alberta, and the southern portion of a depression was apparently moving southeastward along the northern limits of our daily weather map. The center of this depression at no time came within the limits of our stations, and it disappeared on the 21st, p. m., at the Straits of Belle Isle.

XIII.—On the 20th an important depression approached the shores of Washington and British Columbia, and possibly low area No. XII was but the eastern extremity of this larger area advancing from the Pacific and which was apparently then moving northeast over Vancouver Island. On the 21st, p. m., it was central in northern Saskatchewan, and the 22d, a. m., in Manitoba. The center was near Halifax, N. S., on the 23d, p. m., and it passed eastward south of Newfoundland on the 24th.

XIV.—On the 23d pressure fell in Colorado and neighboring states, and low area No. XIV developed in that region without any clearly apparent preceding history, but from the subsequent approach of low area No. XV, as well as the behavior of low area No. XIII, it seems probable that the inflow of air in the rear of low area No. XIII started several whirls in the lower strata far to the south of the main center, and that one of these on the 22d found the conditions on the central-eastern slope favorable to its further development; this appears to be the ordinary history of the origin of new whirls on the eastern Rocky Mountain slope and in the Gulf of Mexico. On the 23d, a. m., the center may be located in western Nebraska, and on the 23d, p. m., in western Kansas, after which it began moving east and northeast. It was central in Iowa the 24th, p. m. On the 25th it passed northeastward over the Lake region, with gales at most stations, the depression being then an ellipse whose longer axis trended northeast and southwest. It moved rapidly over Maine and disappeared south of Newfoundland on the 26th.

XV.—Pressure fell on the 23d on the coast of Washington, and on the 24th the low center passed northeastward into British Columbia just beyond the limits of our stations. Its course during the 24th and 25th is uncertain, but on the 26th, p. m., the low area was central north of Alberta and Saskatchewan, and during the 27th there was a general fall of pressure throughout the Canadian Provinces to the eastward; on the 27th, p. m., the low pressure was central not far north of Lake Superior, after which the southeastward movement changed to northeast, and the depression disappeared on the 29th, a. m., on the Gulf of Saint Lawrence.

XVI.—On the 25th pressure was falling on the California coast, apparently due to the advance of an area of low pressure northeastward toward Oregon; the lowest pressure was apparently nearest the coast of northern California on the 26th, p. m., after which it rapidly filled and entirely disappeared, giving place to high area No. XVI.

XVII.—On the 28th, while high areas Nos. XVI and XVII prevailed over Oregon and Saskatchewan, respectively, a trough of low pressure developed rapidly and pushed southeastward between them from Alberta to South Dakota, and on the 29th, a. m., this trough extended from Montana southeast to Kansas, while a separate branch appeared on the Gulf coast. During the 29th the central portions of the low area filled up, and

the map of the 30th, a. m., shows in its place low areas Nos. XVIII and XIX central in Assiniboia and Alabama, respectively.

XVIII.—This remnant of low area No. XVII extended southeastward on the 30th and then partly filled up, so that on the 31st, p. m., it was still central in Assiniboia.

XIX.—This southern prolongation of the trough, containing low area No. XVII, was central in eastern Texas on the 29th, evidently formed under conditions favorable to a whirl initiated by the southern flow of colder air into the Gulf coast region. While moving eastward it stretched northeastward on the 30th, as a trough over the south Atlantic states, and disappeared on the 31st.

NORTH ATLANTIC STORMS FOR DECEMBER, 1893.

[Pressure in inches and millimeters; wind-force by Beaufort scale.]

The paths of storms that passed over the western portion of the north Atlantic Ocean are shown on Chart I, so far as can be traced from information received up to the 25th of January, through the co-operation of the Hydrographic Office, U. S. Navy, and the "New York Herald Weather Service."

The normal pressure for December, as shown by the international simultaneous observations, is highest, 30.50 (775), in central Asia between E. 80° and E. 110° on the parallel of N. 50°; it is high, 30.20 (797), in the south Atlantic states between W. 80° and W. 90° on the parallel of N. 34°. The pressure is low, 29.60 (752), in Bering Sea between longitude E. 155° and W. 155° on the parallel of N. 55°; it is lowest, 29.50 (752), in the north Atlantic Ocean in an oval stretching from southern Greenland to northern Norway. Between these centers of lowest pressure lies the Arctic region into which storm-centers rarely penetrate very far. Those that have been traced northeastward over the Atlantic during the winter months seem to turn eastward over Norway and Sweden, or if they go past North Cape they are apt to turn southeastward into Russia, and in either case they break up or die out before reaching Siberia. It seems evident that although the mechanical conditions are not unfavorable to the formation of whirls and low pressures within the Arctic circle yet the low temperature and small amount of moisture in the air constitute thermo-dynamic conditions that are unfavorable to the growth and perpetuity of such whirls. It is a matter of almost daily experience to find several independent whirls and low centers included within one large region of low pressure extending from the Aleutian Islands across North America to Greenland and extreme northern Europe, and there can be little doubt but that air flowing as upper southwest currents into such a low region from the regions of high pressure over North America and Asia and over the tropical portions of the Atlantic and the Pacific initiates these separate whirls, but it maintains them only with the help of the thermal disturbances produced by the formation of rain, snow, and clouds.

The normal pressure in December is at the maximum about 0.20 inch lower in the region between Iceland and Greenland than in November, and in general it is lower over the north Atlantic but higher over the tropical Atlantic, and over the interior of the North American continent. The region over which the maximum number of storm tracks was recorded during the years 1878–1887 passes from Japan over the southern extremity of Corea through Bering Sea to the southern extremity of Alaska; thence over the coasts of British Columbia into Oregon; thence nearly due east to southern Newfoundland; thence east-northeast over the Orkney Islands to northern Norway and Sweden; thence southeast to the interior of Russia. Observations are not at

hand to trace this belt of storm-centers from Russia to the Pacific Ocean but the indications are that all cyclonic whirls are dissipated in this region of clear, dry, cold, and probably descending air.

The average velocity of movement of the north Atlantic storms in December is about 21 statute miles per hour over the north Atlantic Ocean, but about 36 miles per hour over the United States, where the movement is more rapid than in any other part of their course from Bering Sea to Europe. During the 10 years, 1878 to 1887, 3 storms were traced continuously over the entire North American continent and the Atlantic Ocean and 1 storm over that continent and ocean and Europe.

During December, 1893, the following areas of low pressure, with revolving winds, have been approximately traced on the Atlantic Ocean:

A. This was the continuation of low area No. II over the United States, as above described; it passed northeastward over southern Newfoundland, and on the 4th apparently approached Iceland.

B. This was central on the 4th, a. m., in the Gulf of Saint Lawrence and was a continuation of low area No. I of the United States series; it passed rapidly northeastward, being south of Iceland on the 6th, after which it turned northward.

C. This was low area No. IV of the United States series; it was central near Cape Breton on the morning of the 6th, and was south of Iceland, approximately at N. 58°, W. 12°, on the 8th, while severe gales raged in the northern part of Great Britain, Ireland, and over the ocean to the westward and southward; it then turned northeast.

D. This seemed to have started as an extreme western branch of C in the region of northwesterly gales that prevailed on the 8th south of Greenland; it was central on the 9th in about N. 58°, W. 28°, and on the 10th, in about N. 55°, W. 12°, as a long oval or trough; it disappeared on the 11th north of Great Britain in the course of the development of a very large area of very low pressure whose center was farther north.

E. This small whirl was located on the 11th as an extension of D to the south-southwest; by the 12th it had moved slightly northward.

F. This whirl was also located on the 11th, when it was west of E in N. 50°, W. 35°; it moved eastward slowly, and on the 12th both E and F were comprised within a trough extending from W. 15° to W. 45° and about N. 52°. Farther west or northwest this trough joined low area No. VII of the United States series, which had extended rapidly northeastward.

G. This was a continuation of low area No. VII of the United States series, which, after moving to the southeast of Newfoundland, turned eastward and joined F and E on the 15th, forming a region of low pressure which at that time